Treatment of Epistemic Uncertainty in Site Effects in Probabilistic Seismic Hazard Analyses

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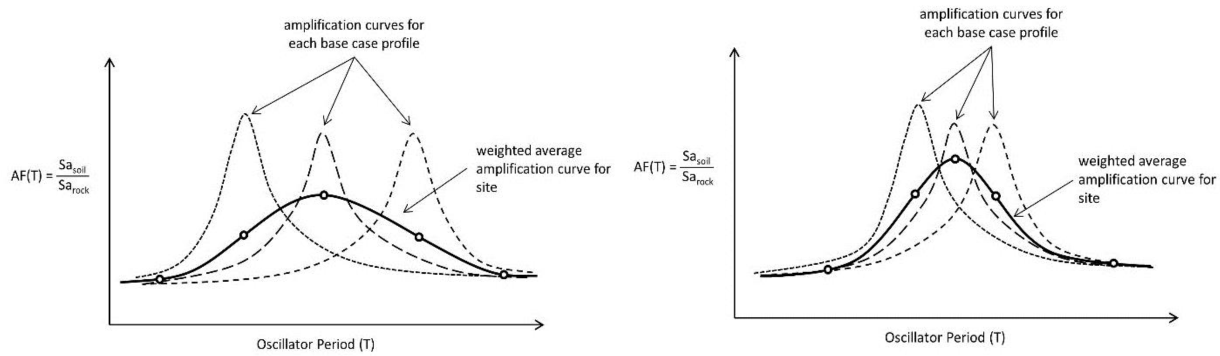
Performance of a probabilistic Seismic Hazard Analysis (PSHA) for a site inherently entails the accounting for site effects, which is the influence of the geologic profile on ground motions as they propagate up from a reference horizon at depth to the ground surface. In 2012, the Electric Power Research Institute published a report that includes a detailed approach for formally incorporating site-specific site effects in a PSHA (EPRI, 2012), to include the treatment of aleatory variability and epistemic uncertainty. This approach has been steadily adopted around the Department of Energy complex. This presentation will outline the EPRI (2012) approach for capturing epistemic uncertainty, identify a shortcoming in the approach, and propose an alternative approach to overcome this shortcoming.

Per EPRI (2012), epistemic uncertainty characterizes the uncertainty in the geologic profile and dynamic properties of the strata (i.e., things that could be determined with certainty given an unlimited amount of time, effort, and budget.) This is reflected, in part, in EPRI (2012) in the development of the best estimate (or mean), lower range, and upper range base case shear wave velocity (Vs) profiles for a site. The lower and upper range base case Vs profiles correspond to the 10^{th} and 90^{th} fractiles of the assumed distribution around the mean base case Vs profile. One guiding principle in estimating epistemic uncertainty is that the less you know, the larger the estimated uncertainty should be. Implied in this principle is that higher uncertainty will result in a higher computed seismic hazard (i.e., higher amplitude ground motions for a given return period). A larger logarithmic standard deviation is assigned to profiles inferenced form geotechnical/geologic information as opposed to profiles developed from data gathered during a detailed site investigation. To compute the surface ground motions corresponding to a given return period, a weighted average of the amplification curves associated with the three profiles is used.

Figure 1 shows conceptual plots of the amplification curves for each base case profiles and the weighted average amplification curves for two assumed values of epistemic uncertainty (i.e., "large" and "small") . In both instances, the weighted average amplification curve corresponding to the larger epistemic uncertainty has a greater bandwidth than the curve corresponding to the smaller epistemic uncertainty, with the bandwidths of both the weighted average curves being much greater than those for the base case profiles. Also, the amplification curve corresponding to the smaller epistemic uncertainty is higher in amplitude than the curve corresponding to the larger epistemic uncertainty over a range of oscillator periods. If the fundamental period of the actual soil profile falls within the range of oscillator periods where the smaller epistemic uncertainty curve exceeds that of the larger epistemic curve, then the computed surface ground motions will be underestimated. This scenario contradicts the spirit of the guiding principle that less knowledge implies higher uncertainty and higher uncertainty results in higher computed seismic hazard.



(a) (b)

Figure 1: Amplification curves for each base case profiles and weighted average amplification curve for: (a) large assumed epistemic uncertainty, and (b) small epistemic uncertainty.

It is proposed that that the amplification curves for the base case profiles be expressed as a function of the ratio of oscillator period to fundamental period of the profile before the weighted average amplification curve is computed. This is conceptually shown in Figure 2, and it can be seen that the weighted average amplification curve has both a bandwidth and amplitude that are statistically representative of the curves for all three of the base case profiles.

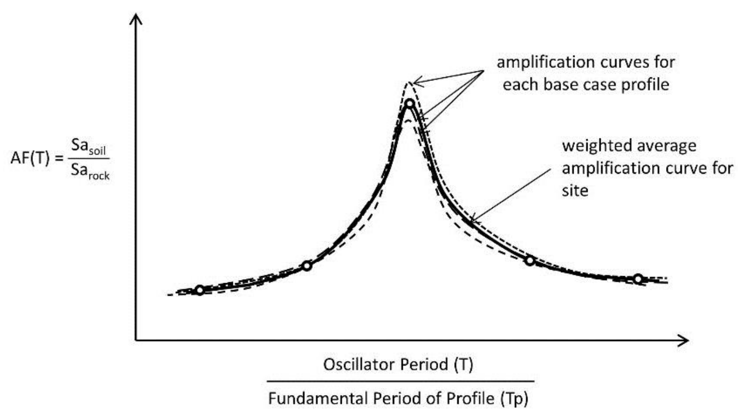


Figure 2: Amplification curves for each base case profiles expressed as a function of the ratio of oscillator period to fundamental period of the soil profiles.

References

EPRI, *Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2:1: Seismic,* Report 1025287, Electric Power Research Institute, Palo Alto, CA, pp. 206, 2012.